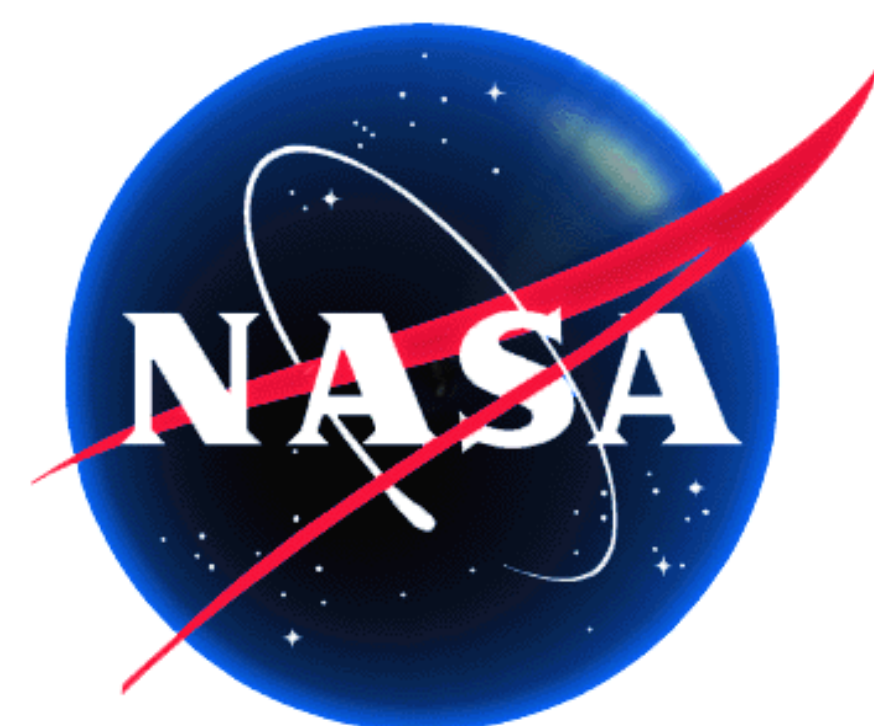


# Low-Finesse Littrow Cavities as Displacement Sensors

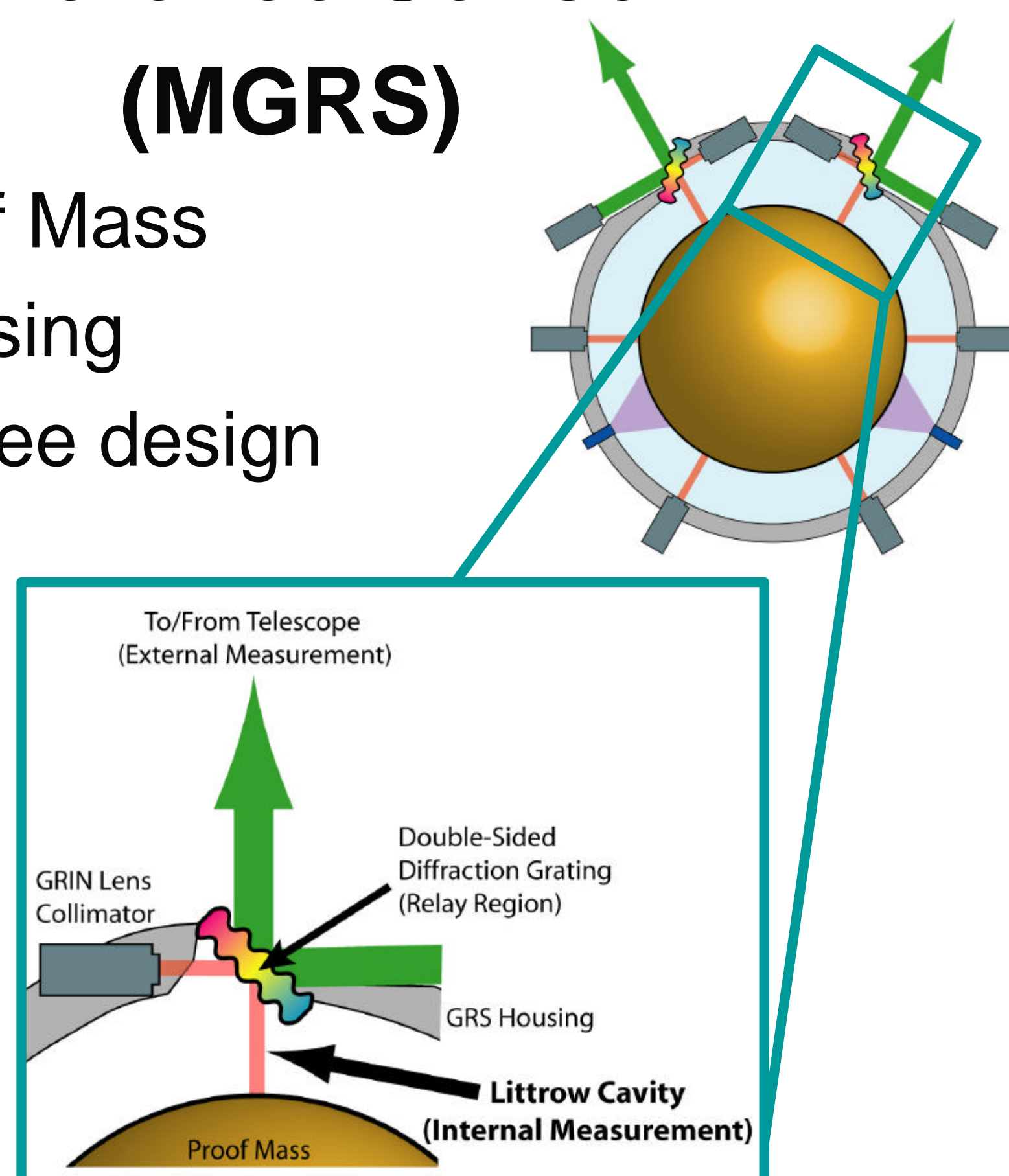


Graham Allen, Ke-Xun Sun, Robert Byer  
Stanford University

gsallen@stanford.edu

## Modular Gravitational Reference Sensor (MGRS)

- Single Proof Mass
- Optical Sensing
- True drag-free design
- Modular
- Large Gap

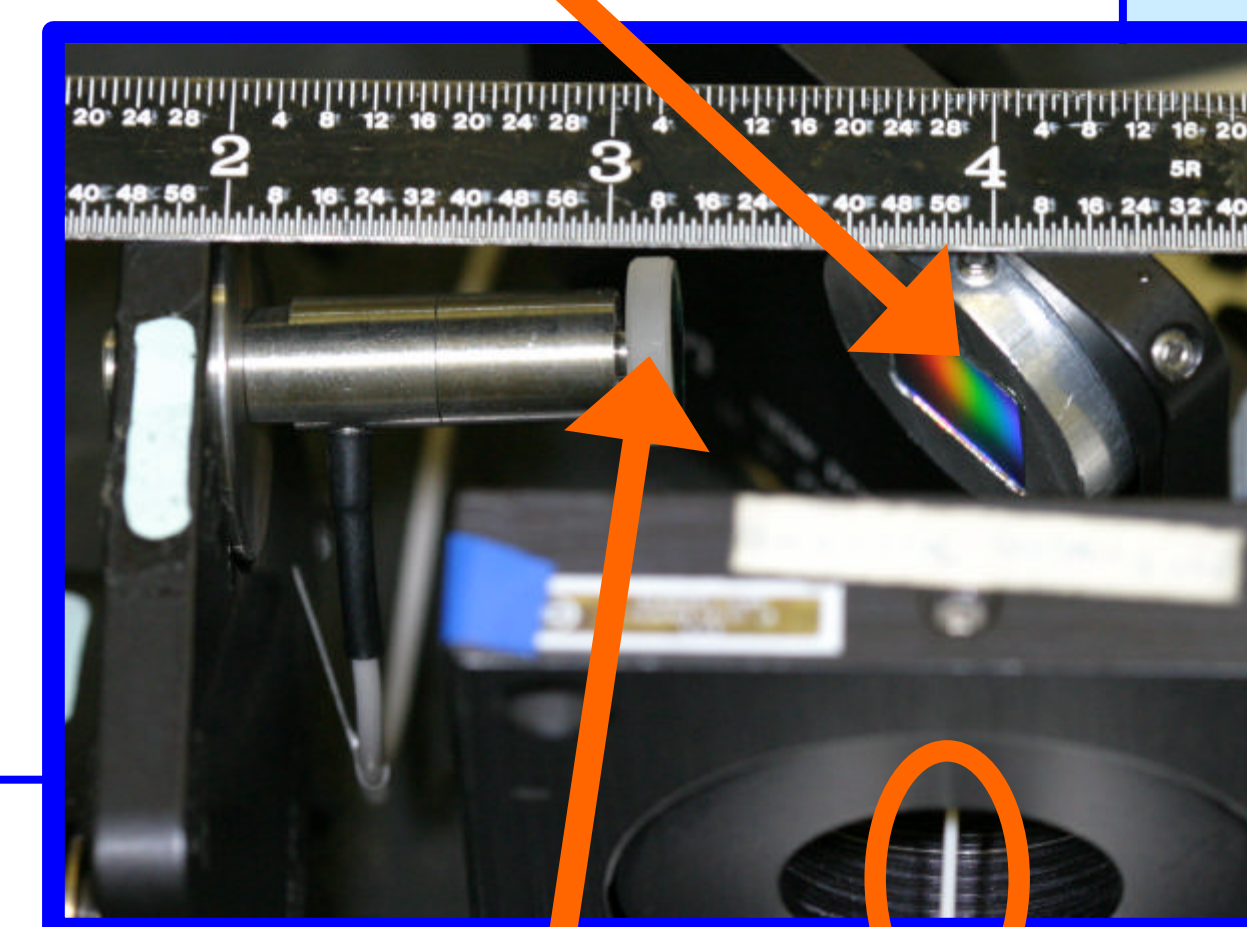


Presented at Amaldi 6 meeting

Ke-Xun Sun, et al. **Modular Gravitational Reference Sensor: Simplified Architecture to future LISA and BBO.**  
*Journal of Physics: Conference Series*, 32:137-146, 2006.

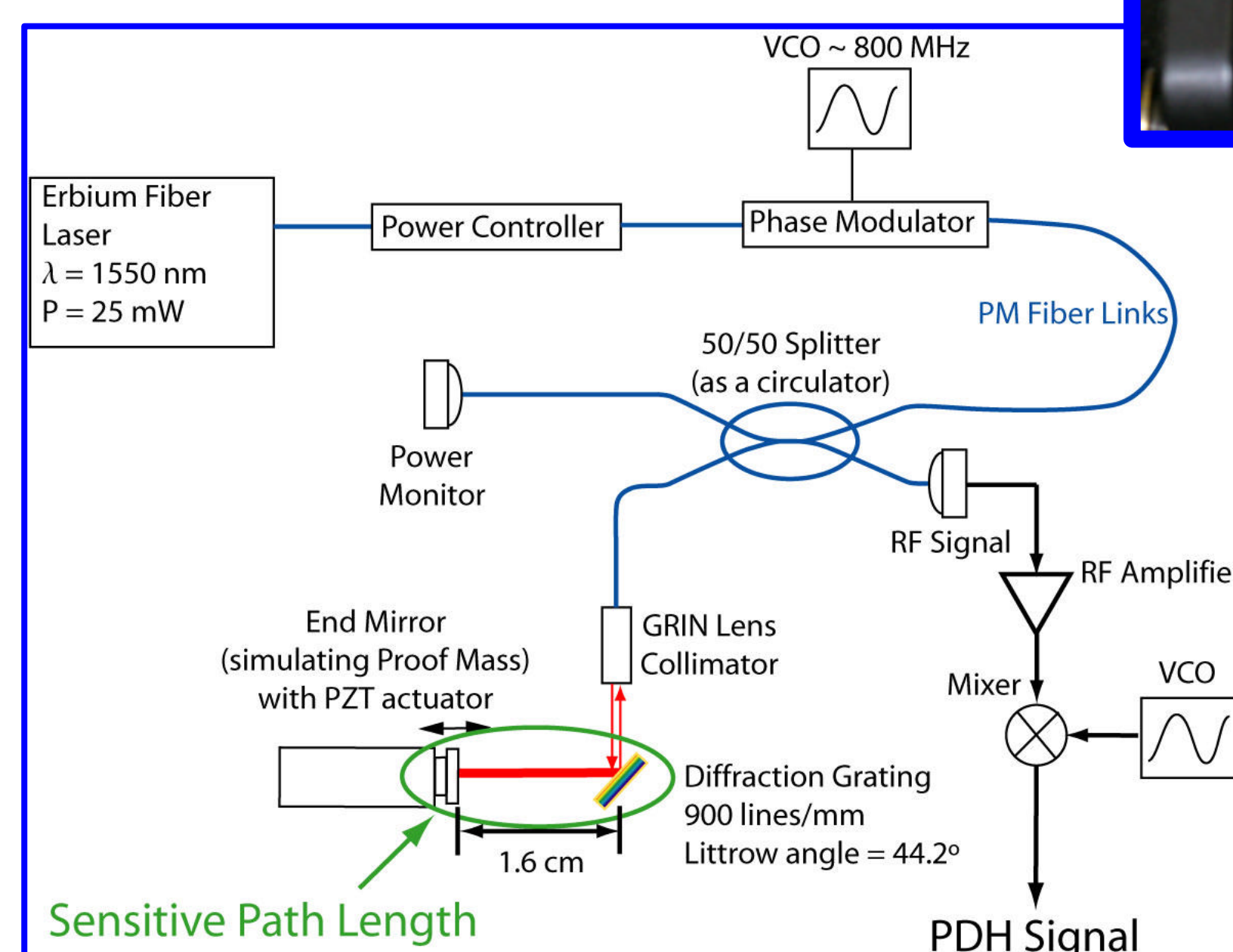
## Experimental Setup

- Commercial Holographic grating
  - 900 lines/mm
  - Flat-Flat cavity
- 1.6 cm cavity length
- 810 MHz RF Sidebands



Mirror mounted on PZT

Optical fiber feed (for GRIN lens)

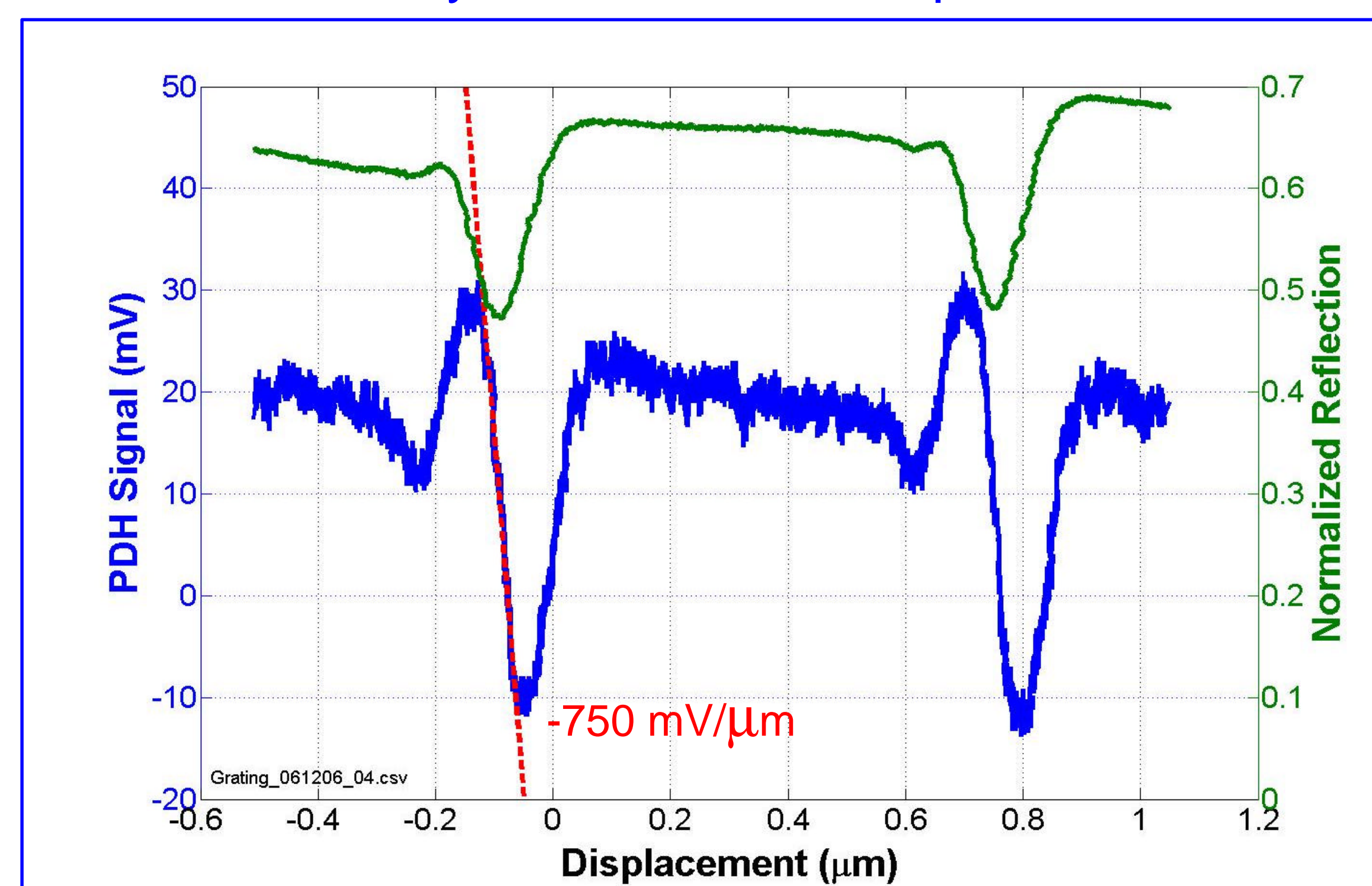


## Sensor Goals

- High precision
  - 1 pm/√Hz in the LISA science band
- Low force
  - Less than 20 μW optical power
- Compact
  - Fiber delivery and read-out

## Preliminary Results

- Cavity properties
  - FWHM = 73.8 nm (Finesse ~ 5)
  - PDH linear range ≈ 100 nm
  - PDH slope = -750 mV/μm
- 10 pm/√Hz above 3 kHz
  - At 100 μW incident power
  - Limited by Johnson noise in photodetector



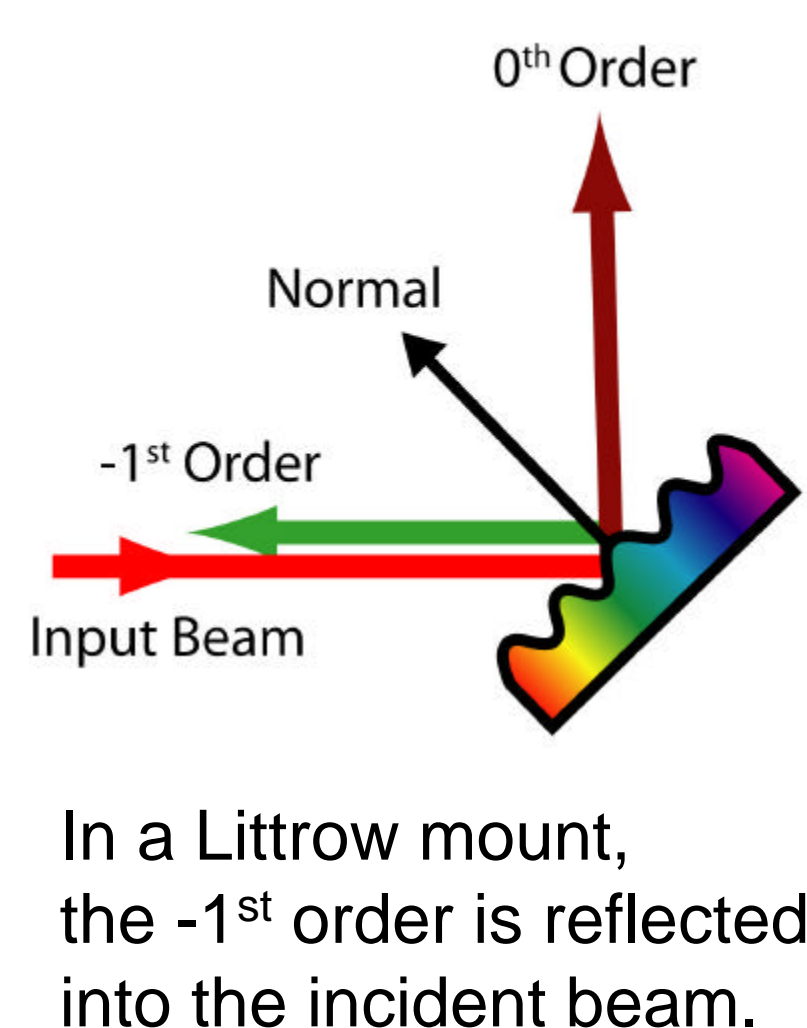
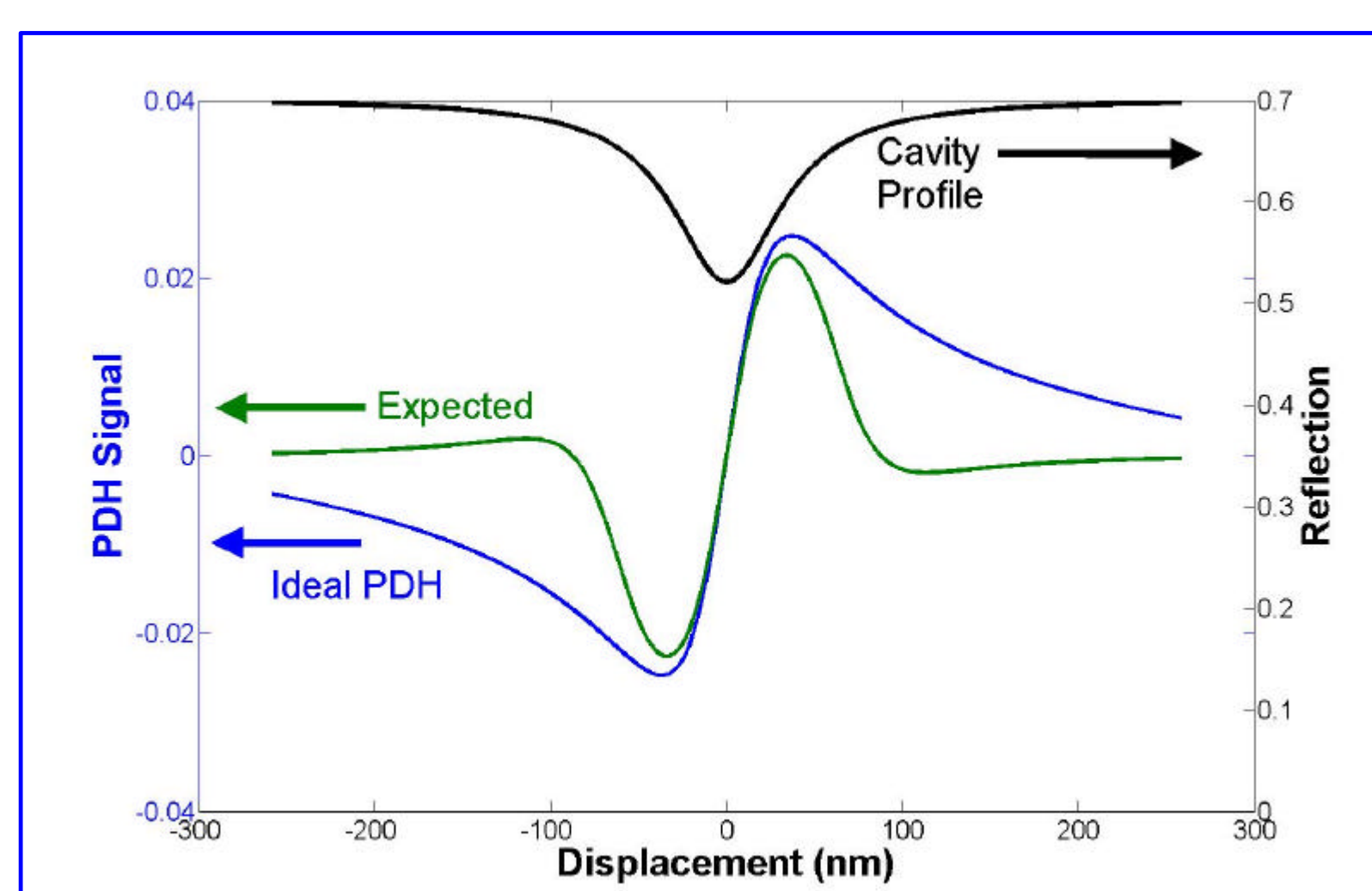
## Measurement Principle

We use a diffraction grating in a Littrow configuration, where the -1 order is reflected back into the incident beam, to form a Fabry-Perot cavity between the grating and proof-mass surfaces.

We then use Pound-Drever-Hall (PDH) RF locking to measure changes in the cavity length.

PDH locking measures the phase shift between the carrier and its RF side-bands.

Using a high-speed fiber optic phase modulator we can add 800+ MHz sidebands to the carrier, ensuring good signal from a low finesse cavity.



Expected signals for our cavity, compared with an ideal PDH signal. In the ideal PDH signal, the side-bands are assumed to be totally reflected, in our cavity, the side-bands are still partially resonant.

## Future Work

- Improved photodetector
  - Narrow-band Avalanche Photodiode
- Investigate low signal strength
  - Signal currently about 10% of simulation estimates
- Polarization Effects
  - S & P cavities have different finesse
  - Can this be used to tune the cavity finesse?